

PSYCHOLOGICAL EFFECTS OF PROLONGED EXPOSURE TO SONAR
SIGNALS AT AN ELEVATED INTENSITY

II. Twenty-four Days' Exposure to Signals at 85 dB

by

Benjamin B. Weybrew

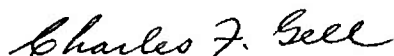
and

Ernest M. Noddin

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Reviewed and Approved by:



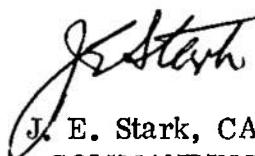
Charles F. Gell, M.D., D.Sc. (Med.)
Scientific Director
NavSubMedRschLab

Reviewed and Approved by:



J. D. Bloom, CDR MC USN
Officer-in-Charge
NavSubMedRschLab

Approved and Released by:



J. E. Stark, CAPT MC USN
COMMANDING OFFICER
Naval Submarine Medical Center

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SUMMARY PAGE

THE PROBLEM

To design and implement a multidisciplinary study to assess the biomedical and psychological effects of 24 days' continuous exposure to an intermittent sonar "beep" at 85 dB.

FINDINGS

Eight of the ten male subjects (5 civilians and 5 Navy sonar-men) while showing a moderate increase in depressive symptoms early in the second exposure phase, demonstrated no remarkable degradation in vigilance, muscle tension, or mood. One civilian subject manifested an anxiety reaction sufficiently acute to warrant his disqualification as an experimental subject about 60 hours after the onset of the sound. Similarly, anxiety symptoms requiring tranquilizer medication occurred in a second civilian subject 5 days before the termination of the "beep". Whereas, the subject selection data argue that this psychopathology existed in these two men prior to the sound exposure, the experimental design does not allow for an unequivocal causal statement.

APPLICATION

This study presents data bearing on the question of whether a nuclear submarine may employ the active sonar mode continuously during prolonged submerged missions without, at the same time, undergoing some degree of degradation in crew member performance and overall quality of adjustment to the submerged conditions.

ADMINISTRATIVE INFORMATION

This investigation was conducted as a part of Bureau of Medicine and Surgery Research Work Unit MF12.524.004-9009DA5K -- Psychophysiological Effects of Prolonged Exposure to the Environment of the Submariner and Diver. It was approved for publication on 6 December 1971 and designated as Naval Submarine Medical Research Laboratory Report No. 691.

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ABSTRACT

Ten carefully screened male subjects, 5 civilian men from the New London community and 5 Navy sonarmen were secluded in the Audiology spaces of the Submarine Medical Research Laboratory for a total of 30 days, 4 pre-experimental (no beep), 24 days exposure to the 85 dB "beep" and 2 recovery days. Administered daily, the test battery consisted of a sequential reaction time test, an eye-hand coordination test, a measure of muscular tension and 4 measures of mood and affect. Although in 8 of the 10 men some depressive trends occurred in the first 3 days of the exposure period, the performance data demonstrated no evidence of significant impairment. Similarly, while three men reported mild reoccurring headaches, and 5 indicated the "beep" may have affected their sleep as well as their performance on certain testing procedures, the overall adjustment of the 8 men did not appear to be impaired allowing 1/2-3 days for adaptation. However, two civilian subjects exhibited symptoms of an anxiety disorder, one acute after 60 hours (requiring disqualification as a subject) and the other benign but chronic with an acute phase requiring tranquilizer medication the last 4 days of the experiment. Whereas the psychiatric test profiles for these two men argue for the existence of the psychopathology prior to the study, the possibility of the sound exposure being an exacerbating factor cannot be precluded from these data.

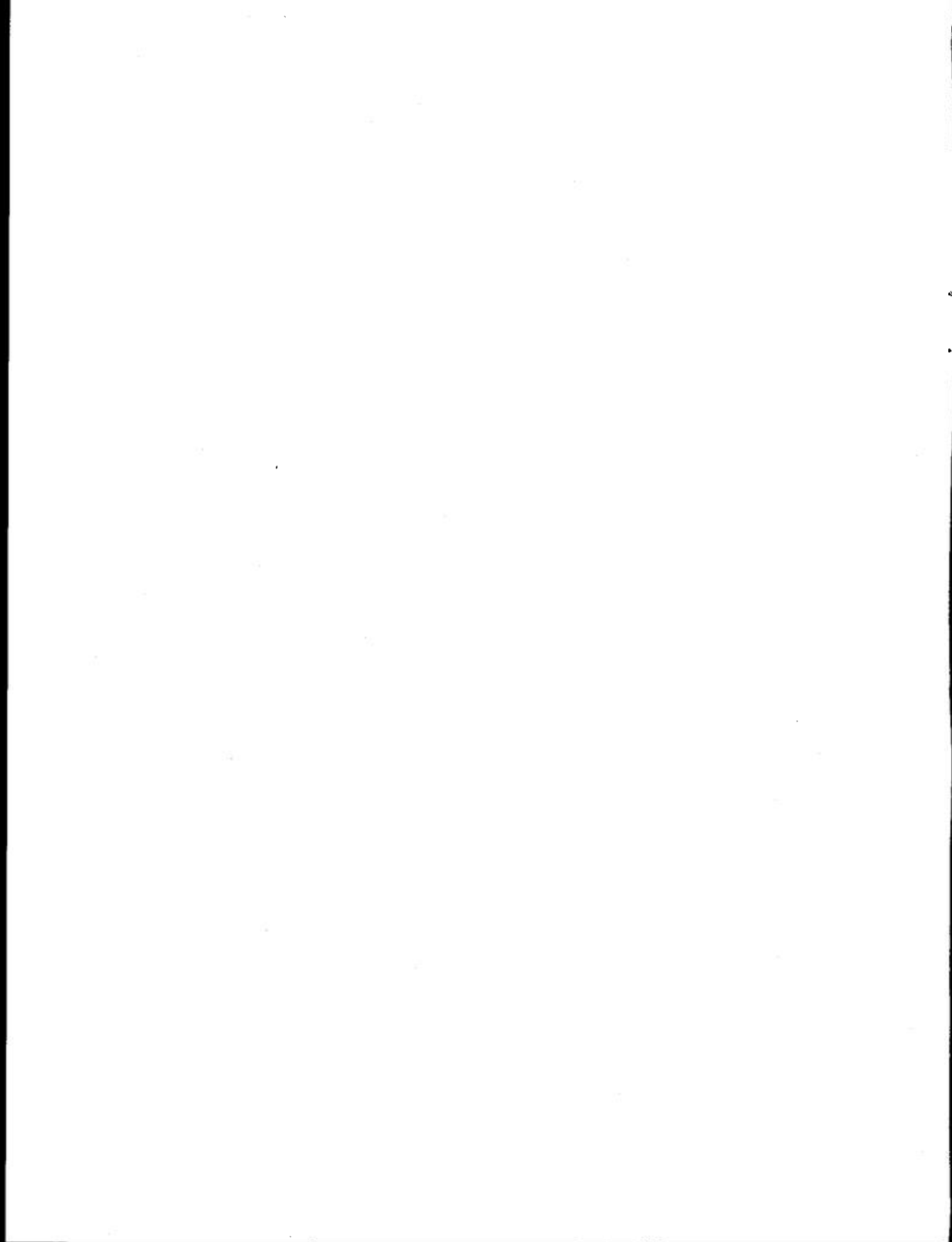
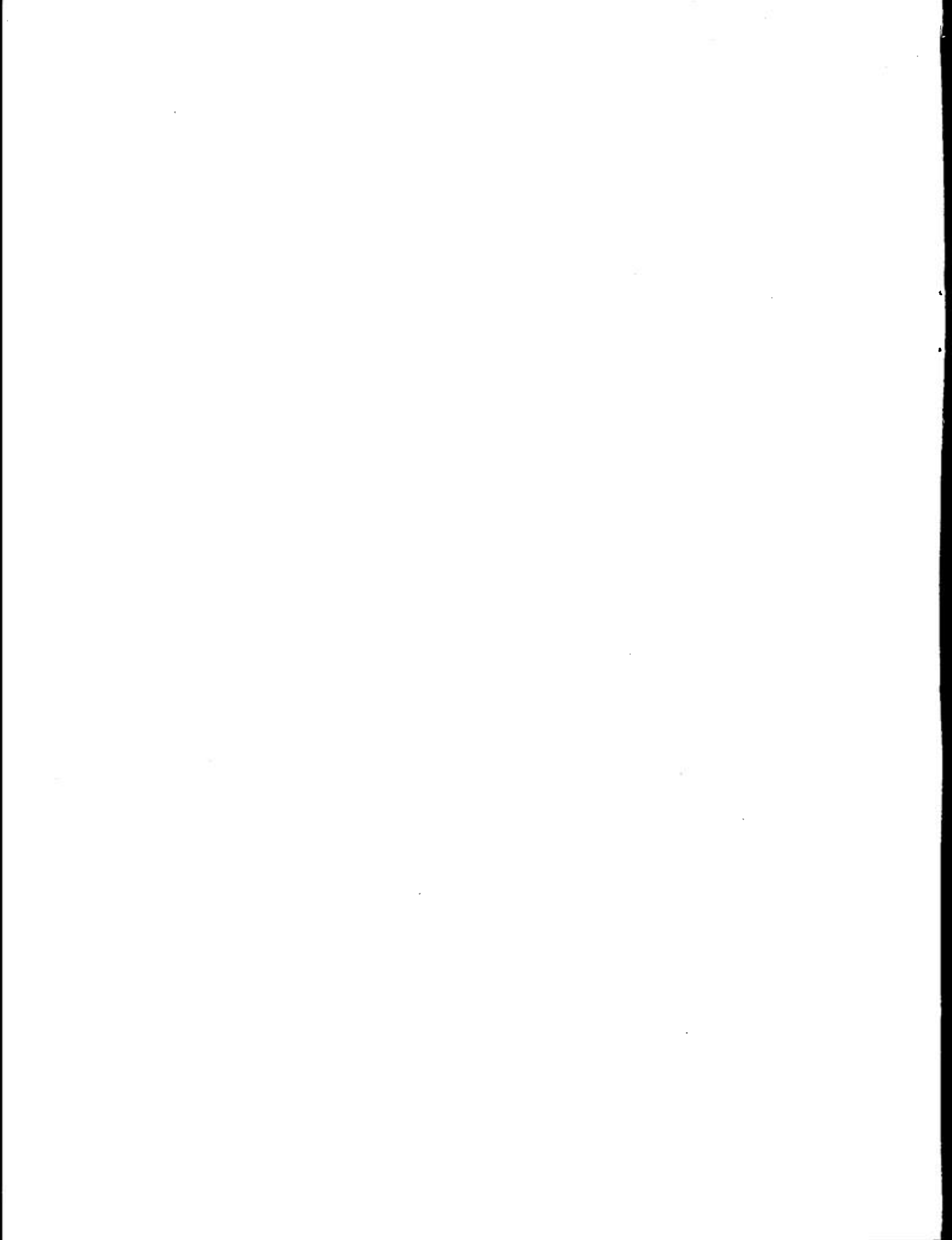


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Psychological Effects of Prolonged Exposure to Sonar Signals at an Elevated Intensity

II. Twenty-Four Days' Exposure to Signals at 85 dB

INTRODUCTION

This is the report of the second Submarine Medical Research Laboratory experiment focused upon an assessment of the psychological effects of long duration exposure to sonar signals at elevated intensity. In general, the results of the first study involving a five-day exposure of 12 enlisted men to 85 dB sonar signals, failed to disclose any acutely maladjustive trends in the data (Weybrew and Noddin, 1971).¹⁰ However, addition test-scores for accuracy dropped the first twelve hours of the experimental period (10% confidence level). Similarly, letter cancellation errors increased (5% level) during the same time span, although sequential reaction time scores from the same test were unchanged. Finally, subjective symptomatology as measured by the Mood Adjective Checklist (MACL) suggested that during the first 12-hour exposure to the sound, hostility, depression tendencies, anxiety level and maladjustive trends all increased (5% level). Quite possibly the most important finding of this preliminary study was the fact that all of the changes observed 12 hours after the introduction of the sound had reverted back to the pre-experimental level 36 hours after the exposure period had started. This finding was construed as an indication that a time span of 24-36 hours is required for optimal adaptation

to this kind of sound exposure. However, one of the twelve men developed a moderately severe tension headache with an associated elevated anxiety level early in the exposure period. Although these symptoms were remitted after two days of treatment with analgesics and sedatives, the experimental design did not provide appropriate data to determine the cause of the symptomatology.

The present study extends the sound exposure duration of the first experiment from 5 to 24 days. While the sound levels for both studies were 85 dB, there were differences in inter-stimulus intervals; namely, 20" in the first study, and 60" in the second. It is also true that not only did the longer exposure period of 24 days more closely approximate the upper limit of submerged missions for nuclear-powered submarines (SSN's), but there was a sizeable effort expended in the second study to impose a more realistic submarine duty cycle upon the subjects throughout the experiment. This aspect of the second study, that is, realistic control of the work-rest cycles of the subjects, lacking in the first study, was considered by the planners of the second study to be an important step in the direction of making the laboratory experiment more relevant for predicting adjustment to submerged conditions.

METHOD AND PROCEDURE

The subject sample consisted of five enlisted Navy sonarmen and five civilians, recruited from an agency and paid the lump sum of \$450.00, for the 30-day study. On the otherhand, the enlisted men whose paygrades ranged from E-4 to E-7, received no additional compensation during the same period, apart from their base pay.

Psychiatric Screening of Subjects

All subjects were administered the Minnesota Multiphasic Personality Inventory (MMPI) (Hathaway & McKinley, 1943) and the SUBMED-RSCHLAB Biographical Inventory (B.I.) (Noddin, 1969)³ prior to the onset of the pre-experimental period. Also, a semi-structured screening interview designed in conjunction with the B.I., was conducted with the majority of the subjects, (Appendix A). All of these data from each candidate were examined with a view of identifying any maladjustive personality patterns which would have a high probability to be contraindicative of optimal adjustment to prolonged confinement.* Impressions pertaining to each man's adjustment status were then integrated by assigning ratings on the nine personality trait dimensions used to screen enlisted submariner candidates (Appendix B). On the basis of this evaluative procedure, two of the seven civilians were disqualified as subjects.

*These psychiatric contraindicators of submarine duty are discussed briefly in Reference 9 - Weybrew and Kinsey, 1968.

The ages of the five Navy men ranged from 18 to 32, with a mean of 22. The 5 civilians had a mean age of 22 and ranged from 18 to 29. The educational achievement of the five Navy men ranged from high school graduate (4 men) to college graduate, one man. On the otherhand, the civilian group contained two high school graduates and three non-graduates. All ten subjects demonstrated functional intelligence of average or higher levels, the average for the Navy group being somewhat higher than that of the civilians as a whole.

Measurement Battery Used During the Experimental Period

In selecting the measures, several criteria for inclusion were imposed. First, each test or measure must have acceptable face validity for the men making up the subject sample. Secondly, the test administrative procedure itself must be brief and unobtrusive. Finally, the measures used must be sufficiently sensitive to reflect subtle effects of chronic but presumably low-level stress. With these criteria in mind, a brief measurement battery was compiled. An abridged descriptive statement regarding the nature and method of administration of each test is presented in Table I.

Multiple-Affect Adjective Checklist

With the exception of the (MACL), the tests described in Table I were administered daily between 1400 and 1600. The MACL data on the otherhand were collected daily, in the evening just before "lights out." In addition, data were obtained about

TABLE I
MEASUREMENT BATTERY

Test or Measure	Rationale	Test Content	Administration and Scoring Procedures
Letter Cancellation	Visual discrimination, eye-hand coordination and sequential reaction time are measured by this test.	Upper Case "C's" are randomly interspersed with "O's".	Time limit 1 minute. Instructions are to put a line through C's only moving from left to right as fast as possible. Type I errors (crossing out O's rather than C's) and Type II errors (failing to cross out C's) are obtainable. Time per response (in seconds) is obtained by dividing 60 seconds by the number of responses.
Hand Steadiness	There is some evidence in the literature of Submarine Psychology (Weybrew, 1957a & 1957b) suggesting that muscular tension as indicated by hand steadiness is a usefully valid index of emotional response to stress.	The test apparatus consisted of a 9-hole Stylus-in-hole device, graduated from 1 mm to 10 mm hole diameters in approximately 1 mm gradations.	The score was the number of contacts made with a 1 mm stylus inserted a standard distance into a 3 mm hole. Each session score in turn was the median of three, 30-second trials interspersed with 15" rest.
Aiming Test	One concomitant of the fatigue and malaise observed during long submerged cruises appears to be a decrement in the ability to carry out sequential acts requiring precision of movement (op.cit.).	Same apparatus as used to obtain the hand-steadiness score.	As rapidly as possible the testee inserts the stylus a standard distance into each of the 9 holes proceeding from largest to smallest. The scores obtained were (1) time for the sequence, (2) number of contacts, and (3) the smallest hole inserted with no-contacts.
Multiple Affect Adjective Checklist (MACL)	Evidence is found in the stress literature suggesting that changes in affect as inferred from subjective report may be one of the most valid indicators of stress effects. (Weybrew, 1963a).	The MACL consists of 132 adjectives factor analytically validated as measures of Anxiety, Depression, and Hostility. ^a A second adjective check list labelled Maladjustive Trends consisted of words originating from the submarine literature. (Weybrew 1963b).	The respondent checks all adjectives describing his affective state at the time. The 4 trait scores were obtained by summing the responses corresponding with the keys provided for each dimension.

^a The MACL was constructed by M. Zuckerman and B. Lubin and is published by Educational and Industrial Testing Service, San Diego, California.

every third day by means of a semi-structured interview form constructed for that purpose (see Appendix C). Finally, on the last day of the recovery phase following the experimental period, a debriefing interview was conducted by the senior author, following rather closely the structured interview outline presented in Appendix D.

Statistical Techniques Employed

The data obtained from each measure were similarly processed, using nonparametric techniques throughout because of the sparsity of the population sample. Since the total sample ($N=10$), was composed of two samples presumably from different populations i.e., five civilians and five enlisted sonarmen, it was necessary to evaluate the statistical significance of these sampling differences for each variable. The significance test employed for this purpose was the Mann-Whitney U-test, (Mann & Whitney, 1947)². Similarly, because of the nature of the population sample(s), the changes in each variable over time were evaluated for statistical significance by means of a nonparametric test appropriate for this repeated-measurement (same subjects) design, namely, the Paired-replicates Sign Test derived by Wilcoxin (1945)¹¹

RESULTS

In the introductory remarks, several differences between the present study and 5-day pilot study conducted in 1970 were pointed out. In order to obtain a meaningful comparison of the results from the two studies, several additional differences between the two

studies should be recognized. Table II presents a comparison of the two studies.

As seen in Table II, in addition to extended duration of the sonar exposure period for the more recent study, there were still other differences, for example, the inter-pulse interval was 3X, the onset of the sonar was at opposite ends of the sleep phase, and the subject sample for the latter experiment was more heterogeneous. Whereas the experimental design employed does not allow for the possibility of gauging the effects of these differences, nonetheless, the discussion of the results to follow will attempt, in some cases at least, to point out possible alternative interpretations of the findings.

Vigilance

The letter cancellation (see Table I) test is designed to measure alertness and sequential reaction time. Fig. 1 presents the line graph of the group means for this variable.

In the first place, it is to be noted that the mean statistics plotted in Fig. 1 are based upon a sample size, $N=9$. This reduction in sample size from 10 to 9 resulted from the necessity of eliminating one man because of a worsening in health status early in the study. In brief*, moderately severe anxiety symptoms appeared in one 19-year old civilian subject about 8 hours after the introduction of the sonar

*A more complete report of this case is presented in the Discussion section of this paper.

Table II. Comparison of the SMRL Brief Exposure Pilot Study With
The Long Duration Sonar, Habitability Experiment

Experimental Design	1970 Study Self - Control	1971 Study Self - Control
Duration of Sound Exposure	5 days	24 days
Duration of Pre/ Post Control Periods	3/2 days	4/2 days
Onset of Sonar Signal	7 p.m. 3rd Control Day.	6 a.m. on 4th Control Day.
Subject Sample	12 enlisted Navy men. No additional pay or compensation.	5 enlisted Navy men; 5 civilians. No addi- tional compensation for Navy men; civilians only received a block sum (\$450.00) for 30- day period.

signal. Then, approximately 35 hours after the onset of the experimental phase of the study, subject "F", apparently unprovoked, showed acute anxiety (panic) symptoms, such as tachycardia, sweating, dilated pupils, expressed fear of death, fear of heart failure (major presenting symptom was pain in upper chest) and fear that "the doctor" would not arrive in time. A complete medical examination including EKG, chest X-ray, and cardiovascular study followed. As a result, "F" was judged asymptomatic and, in less than an hour, he stated his readiness to rejoin the remaining

experimental subjects. However, in the absence of any identifiable sign of organic pathology disclosed by these tests and examinations, the clinical staff agreed that "F" had demonstrated a moderately acute anxiety reaction of unknown etiology. Therefore, based largely upon the man's MMPI profile, it was unanimously agreed that the likelihood of a re-occurrence of similar reactions was high and as a precautionary measure the man should be eliminated as a subject.

As a result, the data obtained from the Cancellation Test was first analyzed

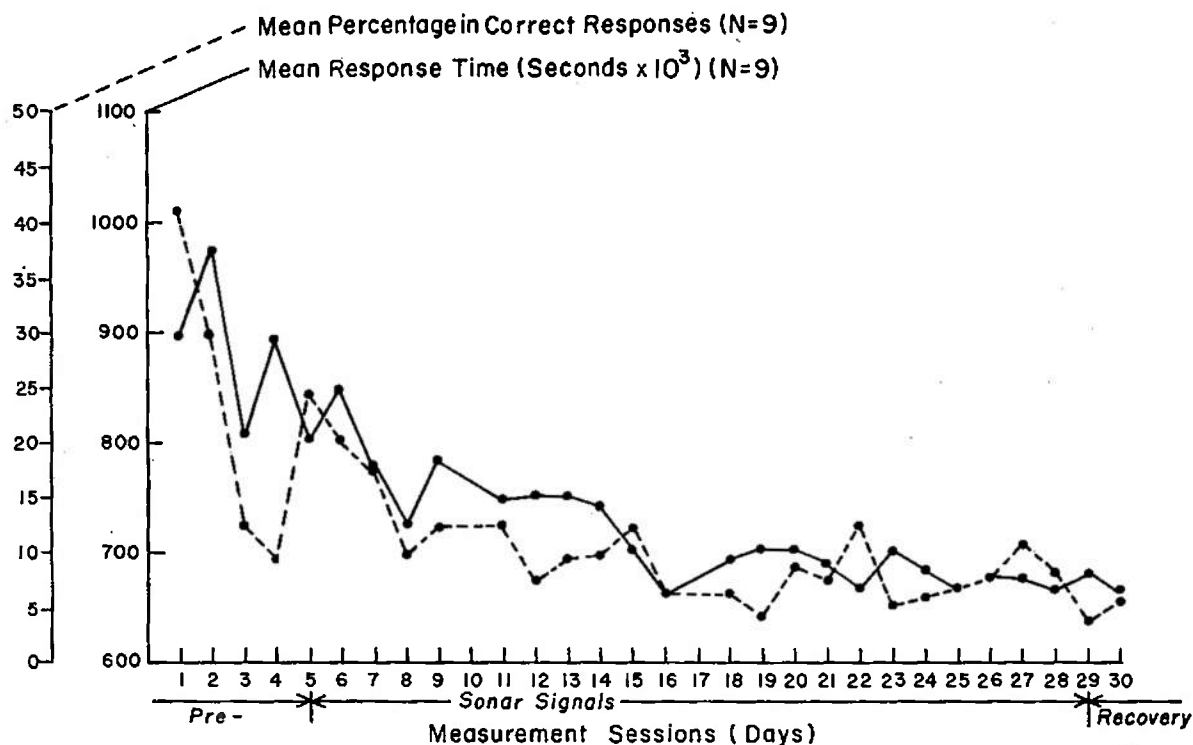


Fig. 1. Sequential Response Time and Letter Cancellation Error Scores

separately for the civilian sample (final N=4) and for the sample of Navy enlisted men (final N=5). Since the differences between the two samples for both scores at all of the points on the abscissa were not significant (5% level, Mann-Whitney Test), the two groups were combined to produce one sample (N=9) upon which the means in Fig. 1 were based.

First, the sequential response time (solid line in Fig. 1) showed a drop on day 5 (8 hours after introduction of sound), then a rise 24 hours later.* At the same time, errors

increased after 8 hours exposure only to decrease 24 hours afterwards. Whereas the means fluctuated for the remaining 20 experimental and 2 recovery days, none of the day-to-day group differences was significant. However, the trends in the graphs for both error and reaction time following day 9 (5th experimental day) suggests a typical learning curve with errors gradually being eliminated and response time accelerated.

Aiming and Hand Steadiness

This rather simple stylus-in-hole technique for detecting subtle changes in eye-hand coordination (aiming) and in muscular tension (hand steadiness)

*Differences mentioned in the text henceforth are significant at the 5% level or less, Wilcoxin Paired Replicates Test

has been used previously in an experiment involving 23 enlisted men incarcerated for 2 months (Weybrew, 1957⁵). Examined by means of factor analysis, the data in the 1957 study suggested that these test scores may be related to individual differences in task motivation, particularly if the tasks are repetitious and somewhat monotonous. Too, muscular tension, particularly as measured by hand steadiness (H.S.) has been shown to be reflective of the general emotional condition of the man at a given time (op. cit.). Fig. 2 presents the plot of the H.S. scores, while Fig. 3 contains similar plots for the three aiming scores.

Hand Steadiness

Again, there were no significant differences between the distributions for the civilian (N=4) sample and the

military sample (N=5) at any of the data points in Fig. 2. Moreover, the means based upon the total sample (N=9) showed no significant (5% level) changes from session to session. Although there was a sizeable drop in the Hand-Steadiness score, indicative of less muscular tension the first 32 hours of the exposure period (10% confidence level), none of the subsequent fluctuations approached significance.

As was the case for the variables in Fig. 1, the trend from the beginning to the end of the sound exposure was toward lower H.S. scores, thus suggesting a slowly developing learning curve. Most certainly, the data were in no way suggestive of any remarkable effect of the 24 day exposure to the sonar signal.

Aiming and Eye-Hand Coordination

Plotted in the same manner as the scores in Figs. 1 and 2, the mean

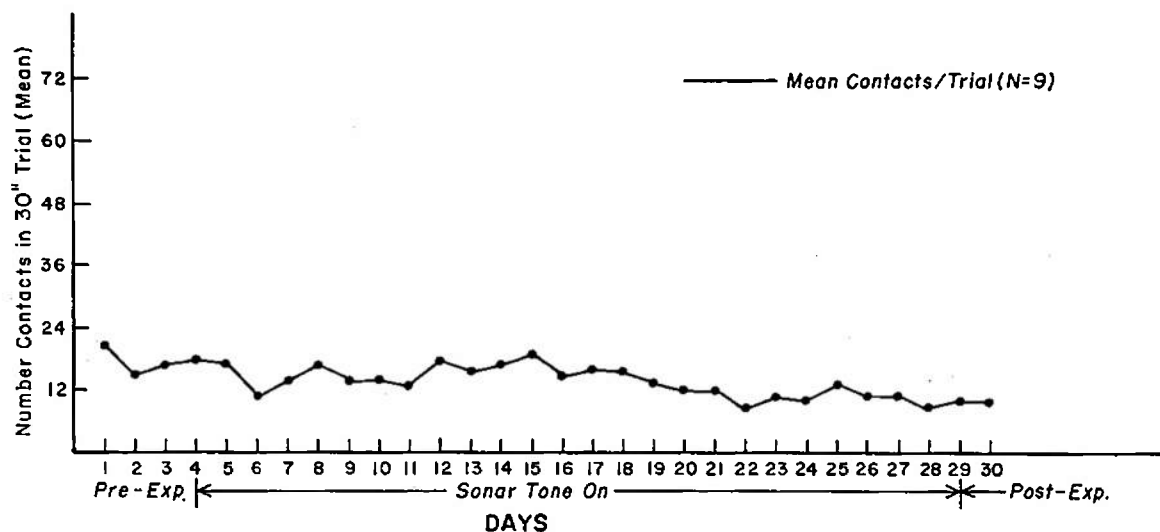


Fig. 2. Hand Steadiness Test Scores

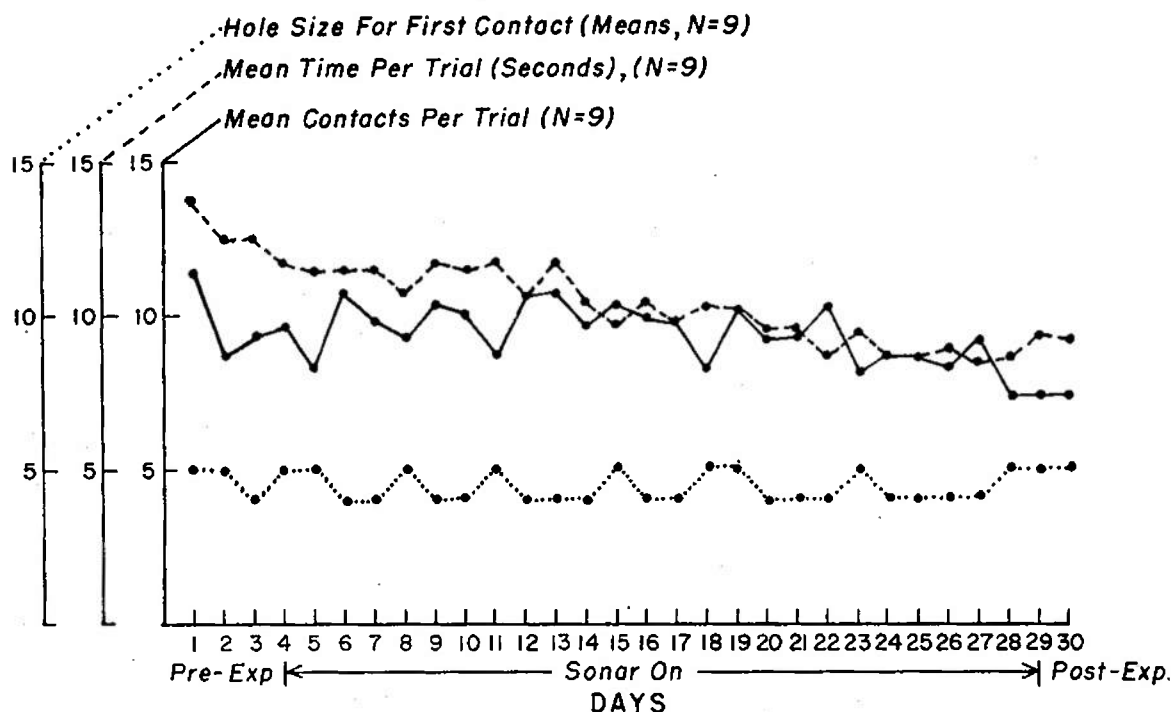


Fig. 3. Eye-Hand Coordination and Aiming Test Scores

scores for the aiming and eye-hand coordination tests presented in Fig. 3 similarly show few trends. Only the aiming score, inferred from number of contacts per trial, showed a possible effect of the onset of the sound. Thus between the 8th hour and 32nd hour of the experimental period, aiming behavior became poorer (6% confidence level) only to revert to control level in the next 48 hours, and subsequently showing again a rather flat learning curve. Similar statements can be made for the speed-of-response score plotted in Fig. 3, except that for this variable there is no significant effect of the introduction of the sound on day 4, yet the distinct learning trend is unmistakable. Finally, the threshold score, i.e.,

the smallest no-contact hole, was plotted as the dotted line in Fig. 3 and demonstrates a typical flat, minimal-learning curve throughout the control and experimental periods.

Mood or Affect Scores

Changes in subjects' affect during the experiment were suggested by the plots of the adjective checklist scores contained in Fig. 4.

A first look at the plots of the three MACL scales (See Table I for a description of the scales), namely, Depression, Hostility, and Depression, yields the impression that the only remarkable change coincident with the onset of the sound is seen in the mean

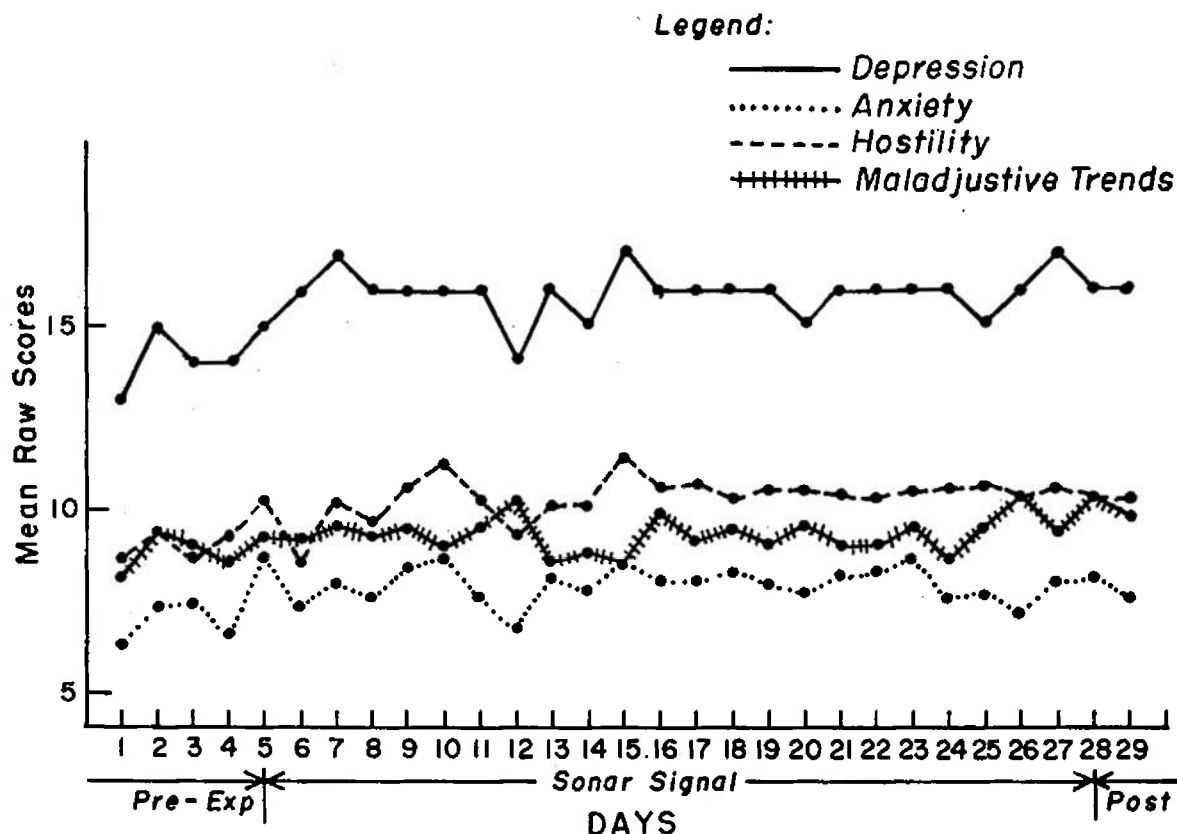


Fig. 4. Multiple Affect Checklist Scores

Depression scores between day 4 and day 7. This reliable (5% level) trend lasts for the 1st 63 hours after the onset of the sound and apparently reverses approximately 24 hours later. A similar depressive trend (5% level) appears about midway into the experimental period or from day 12 to 15 which coincides with the 8th to 11th day of the sound exposure phase. A search of the daily interview data for possible causes of this latter trend showed that day 15 coincided with the first admission of headaches (2 S's) and, at the same time, three different S's noted that the "beep" may be annoying to them in the evenings and

possibly interfering with the onset of sound sleep. Although in the absence of control-group data (i.e., identical data obtained from a similarly confined group not exposed to sound) it is impossible to unequivocally assume the "beep" was causally related to these trends in the data, nonetheless, it appears at least possible that some depreciation in the quality of the groups' adaptation to these conditions did in fact occur at about the 11th day of the sound exposure phase of the experiment.

An obvious point about the subjective data in Fig. 4 is that the ordinate consists of arithmetical means which, of

course, may be affected by extreme deviations in a small fraction of the subject sample. This was certainly true in the case of the high Depression mean score for Day 15 (Fig. 4) which was elevated significantly by one civilian subject's high Depression score on that day. Confirmed during the interview for that day (the 11th day of the sound exposure) and thereafter, subject "B" became increasingly emotionally labile as the experiment progressed. On the 21st day of the experimental period, subject "B" showed anxiety symptoms severe enough for the medical officer to prescribe a minor tranquilizer, diazepam (Valium), 5mg, t.i.d. "B"'s emotional condition improved remarkably within 10 hours, so his dosage of Valium was halved for the remainder of the study in order to lessen the likelihood of the sedative effect of this medication affecting the man's performance on any of the daily measurements being taken. None of the other subjects required psychotropic medication, though one S was given Darvon for toothache, two S's were given Ornade for a poorly-defined cold or allergic condition and one S was given a tetracycline preparation for an acne condition. It was assumed that none of these drugs administered during the study significantly affected the Ss performance. This is believed to be true even for the one man treated with Valium since the therapeutic dosage used was about 1/3 of the common adult dosage. (These drugs are commonly prescribed in considerably greater dosages by Submarine Medical Officers during submerged patrols.)

Post-Experimental Interview Data

As stated earlier, this interview was conducted individually by the senior author of this paper on the final day of the post-experimental recovery period. The interview "probes" for which objective responses were possible were summed for the nine Ss for each item. These distributions together with the interviewers impressions, where appropriate, are contained in Appendix D.

The interview schedule used in these debriefing interviews was modelled after one used with some success to assess the psychological effects of 2 months submergence of submariners. (Weybrew, 1962)⁶. Accordingly, it is seen (Appendix D) that the interview technique involved "probes" requiring rather specific, objective responses which could be complemented by unstructured or open-ended inquiries. Some summarizing statements concerning the results of this interview follow:

1. Insofar as one can assume some useful validity for self-assessment of efficiency, no decrements were thought to have occurred on most of the tasks (1a, 1b, 1c)*.

2. The motivation for volunteering for the study was different for the civilians (N=4) as compared to the military (N=5), viz., quite simply, money incentive for the civilians as

*Refers to the item numbers in the Post-Experimental Interview Schedule contained in Appendix D.

compared to the more lofty motives such as opportunity to learn and to do something valuable for the Navy (2d)*.

3. Surprisingly, there were no pattern differences between the responses of the civilian and Navy subjects to the motivation and attitude items 2a, 2b, and 2c.* Thus, grouping the data, we see 2/3 of the group assessed themselves as being less well motivated about the tests as the study progressed (2a) but at the same time, 7/9 of the group apparently maintained favorable attitudes toward the significance of the study (2c). Similarly suggestive that, for most of the Ss, personal motivation and group morale was reasonably well maintained is the fact that 7 out of the 9 felt satisfied about the outcome of the experiment (2e).

4. With the exception of two Ss (1 civilian and 1 sonarman), little evidence of any remarkable change in affect and mood was observed, (3a, 3b). However, six Ss, apparently because of disturbing "outside" events, reported some emotionally-arousing experiences during the experiment (3c, 3d).*

5. Indicators of deterioration of intragroup rapport were not seen in the Hostility Scores (Fig. 4), but four Ss thought the group's interpersonal irritability increased during the study (4a, 4b). One intergroup dynamism possibly operative in this situation was based upon the seemingly benign negative attitudes between the civilian and

Navy segments of the experimental group (see interviewer impressions, 4c, in Appendix D).

6. As to the vital life habits such as sleep and appetite, the daily interview data as well as the debriefing interview data indicated: (a) little change in eating or elimination habits and (b) of the 5 whose quality of sleep presumably diminished, 3 men considered the "beep" as the probable cause, (5c-1, 5C-3, 6c).

7. Interview Schedule Item 5d indicated the number of men reporting certain, presumable benign, symptoms from time to time during the study. The daily interview data suggests that the 1 major symptom might have been headaches which occurred in at least three Ss from time to time during the experimental period.

8. The question of length of time required to adapt to the "beep" at this intensity varied between 12 hours to 3 days (6a). While the daily interview information tended to support this time span, it is to be noted that seven out of the nine Ss indicated that they continued to notice the sound in the afternoon and evening (6B). Moreover, five Ss thought the sound interfered with certain testing procedures, apparently those requiring rather long periods of sustained attention (6c).

INTEGRATIVE SUMMARY AND DISCUSSION

The use of continuous active sonar mode during submerged missions of 3 weeks or more generates the question as to whether the overall performance

*Refer to the item numbers in the Post-Experimental Interview Schedule contained in Appendix D.

and quality of the crewmembers' adjustment will deteriorate under these conditions. Accordingly, 10 male subjects (five civilian and five Navy sonarmen), mean age 22, were isolated in the Auditory Branch spaces for 4 days preexperimental, 24 days' exposure to an 85 dB "beep" and 2 days' recovery. While this paper reports only the results of measures of sequential reaction time, muscular tension, eye-hand coordination and measures of mood and affect, additional papers in preparation by other department of the Laboratory will contain the results of other aspects of the experiment.

Having checked the between-groups (civilian/military) differences for each measurement session for each test score, the means ($N=9$) for each variable were then plotted over the 30 days (Figs. 1, 2, 3, 4). Using non-parametric tests of significance of change from session to session, it was disclosed that (1) reaction time decreased as did discrimination accuracy the first 8 hours of the sound exposure but for the remainder of the study a gradual learning curve evolved, i.e., trends toward shorter reaction time with fewer errors (Fig. 1); (2) at the same time, muscular tension (Fig. 2) and eye-hand coordination (Fig. 3) did not significantly vary; however, (3) depression scores increased during the early exposure phase.

One difference, among several (see Table 3), between the pilot study (Weybrew & Noddin, 1971)¹⁰ and the present study was the time of onset of the sonar signals. In the first study, the onset time was 1900, before a

sleep period, while the sound was introduced in the present study at 0600, just after a sleep period. This fact may have accounted for some of the differences in the data. For example, in the pilot study greater discrimination errors and faster reaction time were observed, while slower reaction time and no variability in errors were seen in a comparable exposure period in the present study. Also, the subjective indices of Depression, Hostility, Anxiety, and Maladjustive Trends scores all increased significantly in the earlier study, but in the present study only the Depression score was elevated immediately following the sound introduction after the sleep period i.e., at 6 a.m.

Moreover subject sampling for the pilot study was more homogeneous (10 enlisted Submarine School candidates) than the present subject sample which consisted of five civilians and five sonarmen. While both groups in the present study had identical mean ages, the Navy men had higher educational achievement and had been subjected to a more comprehensive medical and psychological screening procedure. Too, the motivational underpinning for volunteering for the experiment was ostensibly different for the two groups. That is, the five civilians, recruited from the sizeable jobless segment of the Groton-New London community, were paid a substantial sum for the 30-day study while the five Navy sonarmen were provided no singular incentive beyond their enlisted pay and allowance. It was indeed incredible that no statistically significant between-group differences

were disclosed for any of the variables included in this part-report of the total collaborative study.

One of the classes of adjustment processes considered most likely to be adversely affected by long exposure to sound stimulation had to do with the possible effects of fatigue induced by a reduction in the quality and quantity of sleep the men were able to obtain under these conditions. The results, obtained from the daily interviews, from the affect and mood ratings and from the post-experimental interviews, suggested that moderate sleep problems, mainly difficulty in going to sleep, were reported for five men. However, of these, only three considered the "beep" the cause of the sleep difficulty. As expected, the most serious sleep problems occurred prior to adaptation to the sound or up to the 3rd or 4th night during the sound-on phase.

Finally, acute decompensatory trends appeared in one of the subjects in the 5-day sound exposure study and in two of the men in the present 24-day exposure experiment. In the earlier study, one Navy enlisted candidate for the Submarine School at New London manifested rather typical symptoms of a moderately severe tension headache the 3rd night of the sound-on phase. Even with appropriate medication, symptomatic relief for this Navy man was not effected until the first day of the sound-off phase. Similarly, in the present study, one young civilian man developed mild anxiety symptoms on day 2 of the sound exposure phase of the experiment, only to exhibit the symptoms of an acute anxiety reaction on the following day. Another civilian, similarly screened

psychologically for the 24-day study, developed a rather diffuse but moderately-acute emotional disturbance, 4 days before the termination of the sound. All of these men required and received appropriate psychotropic medication. The three men from the two experiments were similar also in terms of their personality profiles delineated by psychometric methods beforehand. That is, all three, prior to the onset of the studies demonstrated test score profiles typically found in emotionally unstable persons. While this type of personality frequently adjusts satisfactorily to general submarine duty, it may be that these somewhat disjointed data argue that emotional traits of this kind are contraindicated of optimal adjustment to long-submerged missions; possibly with or without an active sonar system in operation. Appropriate control-group designed experiments are required to unequivocally identify the major causal factors for reactions of this nature.

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PRE-EXPERIMENTAL INTERVIEW SCHEDULE

1.0 General Biographical Information

1.1 Review NSMRL Biographical Inventory (NSMRL B1)

1.11 Indicators of Aptitude Level

1.12 Educational Achievement (B1 #12)

*Graduate High School? Any grade repeated?

If graduated, at what age _____.

1.121 Best/Poorest subjects in High School? (B1 #9, 10, 11)

1.122 If applicable, college history/plans.

*1.123 Attitudes Towards Teachers.

*1.124 Grades in High School.

1.2 Family/Cultural Background

1.21 Marital and Family Status, (B1 #4, 5, 6, 8)

1.22 Job History (B1 #17)

1.23 Father's occupation (B1 #29, 30 31)

*1.24 Geographical area (City, state you spent your years 6-18)

_____.

1.25 Number of times you moved during High School Years? (B1 #18)

_____.

*1.26 Military Service? Number Years _____; Branch _____

*1.261 If discharged before EOAS, type of discharge, Conditions surrounding discharge, etc.

_____.

* Appropriate items both for military and civilians and not tapped by Biographical Inventory (B1), (Noddin, 1969).

2.0 Motivational and Attitudinal Traits

- 2.1 Why did you join the Navy? If appropriate, why volunteer for submarines. In general, how do you like the Navy? The Submarine Service?
- *2.2 Why did you volunteer for this study? With respect to the submarine service, how important do you think it is to conduct this study?
- 2.3 Do you plan to stay in the USN for a full retirement career? If yes, what major goals or objectives do you have? If no, what are your long-term civilian goals or objectives?
- 2.4 What do you like MOST about the Navy? What do you like LEAST about it?
- 2.5 What percentage of Navy men do you think have used or are presently using illegal drugs (exclusive of alcohol)? Have you used any of these drugs? If so, what kind? When was the last time?
- 2.6 What do you think about the militants who refuse to participate in the defense of the United States?

3.0 Emotional Traits

- *3.1 Everyone is moody and nervous from time to time; in comparison to your shipmates, how nervous would you say you are, on the average? Similarly, by comparison, what can you say about your moods from day to day?
- *3.2 Have you ever been hospitalized or treated for any kind of emotional or nervous condition? If so, at what age? If medication was taken, do you know what kind it was? When was the last time any medication of this kind was taken?
- *3.3 Have any of your close relatives ever been hospitalized or treated for any kind of mental problem?
- *3.4 In general, how well do you sleep? Do you generally feel rested when you get up?
- *3.5 Day-in-and-day-out, how does your appetite tend to be?
- *3.6 Everyone loses their temper sometimes; in comparison to others around you, what can you say about your control on the average?

4.0 Character/Behavioral/Social Traits

- *4.1 Excluding traffic violations, have you ever been tried by a judge in a court of law? If yes, may we discuss the situation further?
- *4.2 In general, while growing up, how well would you say you got along with: (a) your teachers; (b) Police and Law Enforcement; (c) your peers (friends)?
- *4.3 People differ in the number of close friends they have; in comparison to others, how many do you have?

5.0 Prodromata of Acute Psychopathology

*5.1 Sensation/Perception

5.11 Orientation (3 modes) Place, Time, Self

5.2 Cognitive functions including memory and attention

5.21 Ability level_____, If USN, GCT_____, Ari_____, Mech_____

5.22	Serial 7's:	Time_____;	Errors
	Color Naming:	Time_____;	Errors

5.3 In the past 10 years, have you ever passed out, or lost consciousness for no apparent reason?

6.0 Interview Summarizing Statements

- 6.1 I have been asking you questions, would you like to ask me any questions? If not, Thank you Very Much.

APPENDIX B

SUMMARY SHEET FOR BRIEF SCREENING INTERVIEWS FOR SUBMARINER CANDIDATES

Name _____ Rank or Rate _____ S/S Class etc. _____

	I	II	III	IV	V	VI	VII	VIII	IX
Extremely Favorable	+4	+4	+4	+4	+4	+4	+4	+4	+4
Somewhat Favorable	+3	+3	+3	+3	+3	+3	+3	+3	+3
Slightly Favorable	+2	+2	+2	+2	+2	+2	+2	+2	+2
Neither Favorable Nor Unfavorable	+1	+1	+1	+1	+1	+1	+1	+1	+1
Slightly Unfavorable	0	0	0	0	0	0	0	0	0
Somewhat Unfavorable	-1	-1	-1	-1	-1	-1	-1	-1	-1
Extremely Unfavorable	-2	-2	-2	-2	-2	-2	-2	-2	-2
	-3	-3	-3	-3	-3	-3	-3	-3	-3
	-4	-4	-4	-4	-4	-4	-4	-4	-4

- I. GENERAL ABILITY/APTITUDE: B. T. B. Scores; Educational Achievement (Grades) and other Indices of Achievement.
- II. BIOGRAPHICAL DATA/DEVELOPMENT HISTORY: Family/cultural background; childhood neuropathic traits; marital and job history (if any), etc.
- III. MOTIVATION FOR THE SUBMARINE SERVICE: Adequacy and appropriateness of goals and motives; mode-to-goal orientation; clarity of goal structure; SMQ Score(s), Reasons for volunteering for Submarines, etc.
- IV. APPROPRIATENESS AND INTENSITY OF ATTITUDES: Attitudes towards: militant pacifism, toward the Navy as a whole, towards the Submarine service, towards authority in general, Rigid social prejudices.
- V. CHARACTER OR BEHAVIORAL TRAITS: Evidence for, or absence of maladjustive trait development, psychopathic or dyssocial trends, personality trait or pattern disturbances, History of adjudicated crime, etc.
- VI. SOCIAL TRAITS: Social adaptability, etc.
- VII. NEUROTIC TRAITS: Frequency and severity of neurotic symptoms (PIB Score) in the context of characteristic ego defense strategy(s).
- VIII. ACUTE PSYCHOPATHOLOGY: Evidence for incipient pathology, trends prodromal of psychosis; confusion for time and place, reality contact, memory lapses, inappropriate or exaggerated affect, motor disturbances, perceptual disturbances, delusional trends.
- IX. OVERALL ADJUSTMENT POTENTIAL: Evaluation of man's overall adjustment for the Submarine Service.

Prepared for Experimental Use by:

Benjamin B. Weybrew PhD

APPENDIX C
INTERVIEW OUTLINE

1.0 Sleep

- 1.1 Does beep interfere with your going to sleep?
- 1.2 Does it awaken you during the night? Number of times_____.
- 1.3 Do you characteristically feel more or less rested than you usually feel after a full night's sleep?
- 1.4 How many hours' sleep did you get in the past 24 hours?
 - 1.4.1 Did you nap during the day? Ordinarily (before the study) did you characteristically nap?
- 1.5 Can you recall any dreams you've had during the past sleep period?
Would you say you are dreaming more or less than you usually do?
Dream content? Dreams pleasant/unpleasant?

2.0 Primary Habit Changes

- 2.1 Food Appetite, more or less? Any food preference changes?
- 2.2 Changes in elimination habits?

3.0 Sensory/Perceptual Processes

- 3.1 Does "beep" seem louder? Softer?
- 3.2 When do you notice beep? early a.m., before sleep, while doing tests, etc.?
- 3.3 If at all, when or under what conditions do you notice the "beep"? Does it interfere with your performance on any of the tests?
- 3.4 Any changes in vision, e.g., the way the rooms look, vertically/horizontally, etc.?
- 3.5 Subjective temperature changes? Cold_____Hot_____.

4.0 Motivational, Attitudinal and Interpersonal Processes

- 4.1 Have you felt like putting out maximum effort on all of the tests?
Which test or procedure (if any) is most annoying and or uninteresting to you?
- 4.2 In general, how have your attitudes been? Towards the experimenters?
Towards the other subjects? Toward the relevance (importance) of the study as a whole?

5.0 Emotional and Affective Response Patterns

- 5.1 As compared to your average, have you been More_____, Less_____,
The Same_____ in terms of irritability toward the other subjects?
- 5.2 In terms of tension (uptightness) have you been More_____, Less_____,
The Same_____ in the past 24 hours?

6.0 Symptomatology

- 6.1 Any headaches? Where?_____ Severity_____.
- 6.2 Eyes blurred?
- 6.3 Ears ring? Time of day most annoying_____
- 6.4 Pain or tension in abdomen area?_____.

POST EXPERIMENTAL INTERVIEW SCHEDULE

Name _____ Date & Time _____

Information Concerning Interviewer's
IMMEDIATE Pre-interview duty _____1. PERFORMANCE ON DUTY

- a. Would you say YOUR performance in the experimental tests became LESS efficient, MORE efficient or remained the SAME as the study progressed?

Interviewer Check	
MORE	4
LESS	_____
SAME	5

- b. In general, would you say the performance of the group as a whole became LESS efficient, MORE efficient, or remained the SAME?

MORE	4
LESS	_____
SAME	5

- c. What else would you like to say about YOURS or the Crew's performance during the study?

No Comment	5
Continuous Improvement	1
"Beep" did not bother	1
Noise may be stimulant	1
Learning/practice on "Tracking" and slack important	1

- d. Interviewer's Post-interview impressions with respect to man's probable performance, etc.
With the exception of 25s (1 civilian and 1 navyman) the subjects' performance level was not significantly degraded by motivational deficiencies (boredom).

2. MOTIVATION, ATTITUDES, ETC

- a. As the study progressed, did you feel MORE enthused about the tests day in and day out, LESS enthused or ABOUT THE SAME?

MORE	1
LESS	2
SAME	2

- b. As time went on did you notice that your desire for "outside" activities became MORE intense, LESS intense or remained about the SAME?

MORE	6
LESS	_____
SAME	3

- c. As the experiment went on did you become MORE impressed by the importance or significance of the study, LESS or ABOUT THE SAME?

MORE	2
LESS	2
SAME	5

- d. Why did you volunteer for this experiment?

	Civilian (N=4)	Military (N=5)
Extra Money:	4	_____
Room & Board:	_____	_____

Appendix D (Cont'd)

Duty Change: (Better, different duty;
get away from outside).

Chance to Study, Learn
Importance (Value) to USN
Proud I can adapt to Subs

Civilian (N=4)	Military (N=5)
1	3
	2
	1
	1

a - Number of subjects indicating the particular response.

e. At this time, do you feel MORE satisfied, LESS satisfied, or about the SAME with having volunteered for the experiment as you did before the start of the experiment?

MORE	7
LESS	
SAME	2

f. Interviewer's Post-interview impressions: Judging from the content and emotional "tone" of the interviewer's responses, there appears to be little doubt that the dollar-incentive for the civilians was effective. Mild resentment was observed in the sonarmen subjects, but it is difficult to ascertain the effect (if any) the lack of money incentive may have had upon the task motivation of the 5 navymen.

3. AFFECT AND/OR EMOTIONAL STATUS

a. As the study progressed, do you think you became MORE HAPPY, LESS HAPPY, or ABOUT THE SAME?

MORE	2
LESS	2
SAME	5

b. As time went on, do you feel the group as a whole became MORE HAPPY, LESS HAPPY, or ABOUT THE SAME?

MORE	
LESS	2
SAME	7

c. Was there any time during the study that you felt extremely anxious or up-tight about something or someone?

YES	6
NO	3

d. Interviewer's Probe re: Source of anxiety and the time during the experiment that it occurred. Can "S" state whether the problem (anxiety) was caused by factors within the study or from some "outside" cause(s).

YES	4
(Outside Cause)	
YES	2
(Inside Cause)	
NO	3

e. During the study, did you have MORE, LESS, or ABOUT THE SAME number of dreams than you usually have?

MORE	2
LESS	2
SAME	5

f. As time went on, did your dreams become MORE PLEASANT, LESS PLEASANT or about the SAME in terms of PLEASANTNESS?	MORE	<u>2</u>
	LESS	<u>2</u>
	SAME	<u>5</u>

g. Interviewer's probe re: Most frequently reported DREAM CONTENT. Dream about family, children etc. No dream content reported that could be construed as being even remotely associated with the continuous exposure to the Sonar signal.

h. Interviewer's impression re: General emotional status of man.

4. INTERPERSONAL PROCESSES

a. With time, did you feel that you became MORE irritable, LESS irritable, or remained about the SAME in your interaction with your shipmates?	MORE	<u>3</u>
	LESS	<u> </u>
	SAME	<u>6</u>

b. As a whole, do you think the subjects became MORE irritable, LESS irritable, or remained ABOUT THE SAME while on duty, recreating, etc.?	MORE	<u>4</u>
	LESS	<u> </u>
	SAME	<u>5</u>

c. Interviewer's impressions, re: This man's attitudes toward group. Two of the military Ss were observed in some rather aggressive behavior directed, for the most part, toward 1 civilian. Apparently supporting this aggressive behavior, which occurred 6-8 times, were hostile attitudes which did not seem to intensify after the first 6-7 days in the sound.

d. Interviewer's Attitudes toward interviewee.

5. PSYCHOSOMATIC AND/OR PSYCHOPHYSIOLOGICAL SYMPTOMS

a. As the study progressed, would you say you were able to get MORE sound sleep, LESS, or ABOUT THE SAME as you are usually able to get under normal conditions?	MORE	<u>2</u>
	LESS	<u>2</u>
	SAME	<u>5</u>

b. During the study, would you say your appetite INCREASED, DECREASED, or stayed ABOUT THE SAME?	INCREASED	<u>3</u>
	DECREASED	<u>6</u>
	SAME	<u> </u>

b-1. Has there been any significant change in your elimination habits during the study?

YES 2 NO 7

b-2. Weight change: NONE 4; GAINED 3; LOST 2

c. During the experiment, did you have any physical complaints - YES or NO.

YES 4
NO 5

c-1. During the study, has it taken you any longer to go to sleep than before the study?

YES 5 NO 4

If yes, do you think this was because of the "Beep"? YES 1; NO 4.

c-2. On the average, how many times did you typically awaken during a night's sleep?

NONE 5; ONCE OR TWICE 3; MORE THAN TWICE 1.

c-3. Did the "Beep" awaken you?

YES 1 NO 8.

d. If you have had symptoms, for example, headaches, blurred vision, ringing in ears, etc., can you be more specific about the location of the symptom, its severity, etc.?

Ringing in Ears	<u>1</u>
Eyes burn	<u>3</u>
Toothache	<u>1</u>
Chest Pains	<u>1</u>
Headache	<u>3</u>
Earache	<u>1</u>
Cold (s)	<u>3</u>
Vague Dull Aches	<u>1</u>

e. As time progressed would you say you became MORE ALERT, LESS ALERT, or ABOUT THE SAME, as usual?

MORE 4
LESS 1
SAME 4

Appendix D (Cont'd)

f. As time passed, do you feel you became MORE TIRED OUT, LESS TIRED OUT, or remained ABOUT THE SAME?

MORE	<u>3</u>
LESS	<u>1</u>
SAME	<u>5</u>

g. Do you think that being confined to the laboratory and being exposed to this "sound" "beep" for so long a period of time has harmed you in any way?

YES _____ NO 9

h. If yes, in what way do you think it has harmed you?

6. ABOUT THE "BEEP" ITSELF?

a. How long after the "Beep" came on would you say it took to get used to it?
1/2 day or less 3; 1 day 2; 2 days 2; 3 or more days 2.

b. What time of the day did you notice the sound most? (if at all)
Didn't Notice it 2; Late afternoon 2; Before sleep period 5.

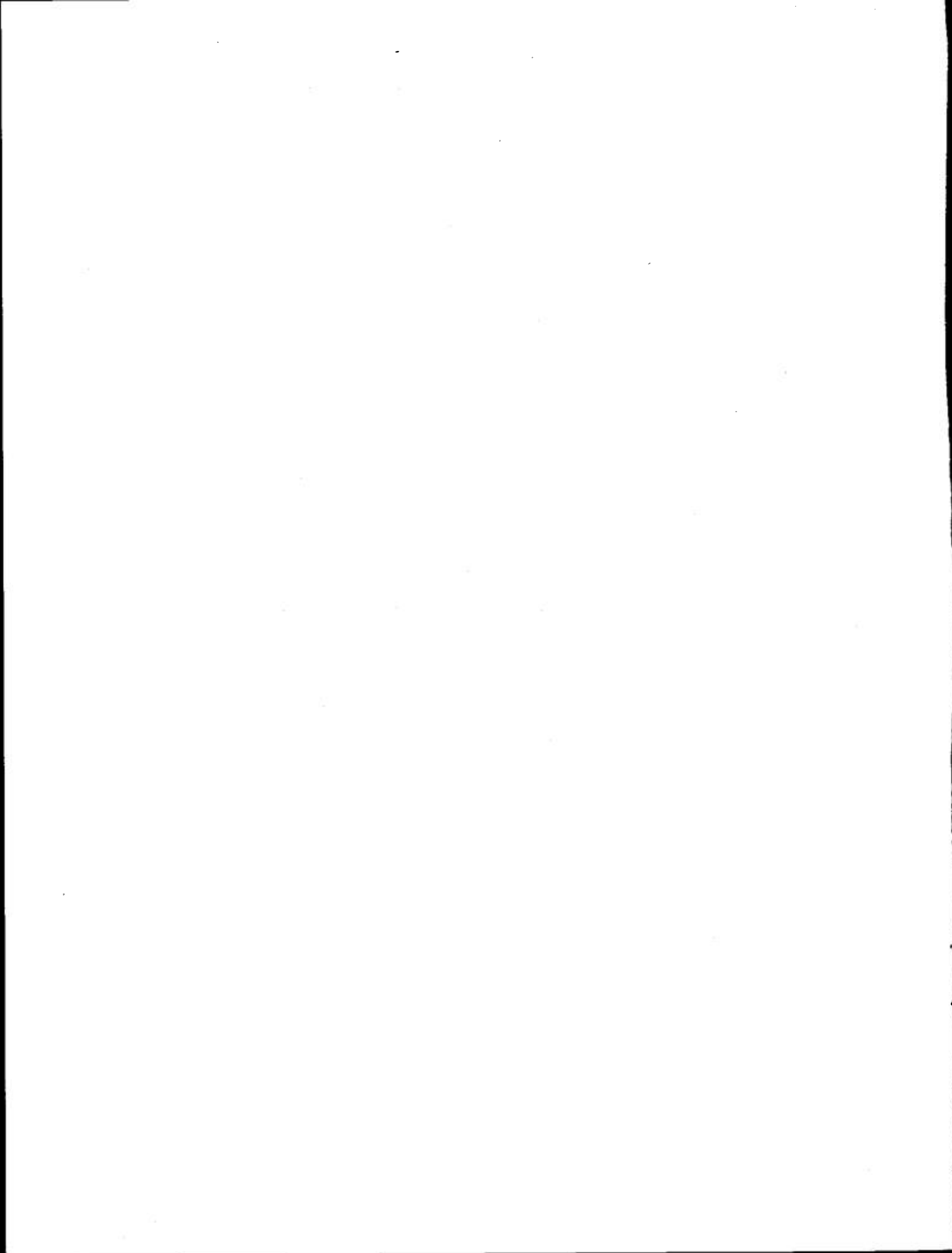
c. Do you think the sound interfered with: (1) your sleep; (2) your performance on any of the tasks (if yes, which one); (3) your emotions (anger, sadness, etc.)?
Sleep 3; Test Performance 5; Emotions 1.

Tests Mentioned: Stack 1; Audiometric 1; Visual Evolved Potential Group Test (Dots) 2.

INTERVIEWEE'S ATTITUDE

a. During the interview, what was the interviewee's attitude toward the interviewer?

V. COOP	<u>3</u>
COOP	<u>6</u>
INDIF	_____
RESISTANT	_____
V. RESISTANT	_____



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13. ABSTRACT Ten carefully screened male subjects, 5 civilian men from the New London community and 5 Navy sonarmen were secluded in the Audiology spaces of the Submarine Medical Research Laboratory for a total of 30 days, 4 pre-experimental (no beep), 24 days' exposure to the 85 dB "beep" and 2 recovery days. Administered daily, the test battery consisted of a sequential reaction time test, a hand-eye coordination test, a measure of muscular tension and 4 measures of mood and affect. Although in 8 of the ten men some depressive trends occurred in the first 3 days of the exposure period, the performance data demonstrated no evidence of significant impairment. Similarly, while 3 men reported mild re-occurring headaches, and 5 indicated the "beep" may have affected their sleep as well as their performance on certain testing procedures, the overall adjustment of the 8 men did not appear to be impaired allowing 1/2 - 3 days for adaptation. However, two civilian subjects exhibited symptoms of an anxiety disorder, one acute after 60 hours (requiring disqualification as a subject) and the other benign but chronic with an acute phase requiring tranquilizer medication the last 4 days of the experiment. Whereas the psychiatric test profiles for these two men argue for the existence of the psychopathology prior to the study, the possibility of the sound exposure being an exacerbating factor cannot be precluded from these data.		

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